Appendix B

Pathogens

Transmission of Pathogens

Pathogen levels in wastewater reflect the presence or absence and level of pathogens in the general population served by the municipal facility. Wastewater treatment processes are designed to reduce the presence of pathogens in treated discharge water. In addition, there are several treatment processes that are used to reduce the pathogen content in the residual solids. The Part 503 rules specify these pathogen limits for two classes of pathogen reduction, Class A and Class B, in treated solids (see Tables B-2 and B-3).

In assessing the disease potential of biosolids or of a storage situation, the amounts of pathogen present as well as the potential routes of infection, the likelihood of a person contacting the source of the pathogen, the success of storage containment, as well as the amount that a person would potentially ingest or inhale if containment failed, and the virulence of the disease agent must all be taken into account. This type of information is essentially the same as that used to assess the disease potential of infectious pathogens that we contact in our daily activities (involving hand-to-hand, hand-to-eye, hand-to-mouth contact with pathogen sources, or inhalation and/or ingestion). It is clear from our knowledge of daily activity exposures that only some exposures result in disease. This may in part be attributed to the fact that some are more intense than others, e.g., the intense exposure to air in enclosed areas like commercial aircraft cabins, movie theatres, schools, and daycare centers; or, food and beverages prepared, imported, and/or served commercially by persons carrying and possibly transmitting a variety of microorganisms; or simply hand shakes with friends and colleagues. When disease occurs, we know that the amount of the pathogens present, their virulence, the person's susceptibility, and the exposure route were all sufficiently above the threshold levels that result in an infection. Fortunately, most daily activities do not result in disease.

During the course of wastewater treatment, the microorganisms in sewage are reduced in number, and become concentrated in the solids. Untreated

(unstabilized) solids have a greater potential to contain significantly larger amounts of pathogens than do solids that have been treated with pathogen reduction processes that result in Class A or Class B biosolids according to Part 503 rules. Class A biosolids have no detectable pathogens, whereas Class B biosolids have significantly reduced levels of pathogens. Hence, the part 503 rule specifies site access and crop harvesting restrictions for Class B biosolids so they can be safely land applied. For these reasons, it is recommended that only Class A or B biosolids intended for land application be brought to field sites/facilities for storage.

Table B-1. Major Pathogens Potentially Present in Municipal Wastewater and Manure*

Bacteria	Disease/Symptoms for Organism
***Salmonella* spp.**	**Salmonellosis (food poisoning), typhoid**
***Shigella* spp.**	**Bacillary dysentery**
***Yersinia* spp.**	**Acute gastroenteritis (diarrhea, abdominal pain)**
Vibrio cholerae	**Cholera**
Campylobacter jejuni	**Gastroenteritis**
***Escherichia coli* (enteropathogenic)**	**Gastroenteritis**
Viruses	
Poliovirus	**Poliomyelitis**
Coxsackievirus	**Meningitis, pneumonia, hepatitis, fever, etc.**
Echovirus	**Meningitis, paralysis, encephalitis, fever, etc.**
Hepatitis A virus	**infectious hepatitis**
Rotavirus	**Acute gastroenteritis with severe diarrhea**
Norwalk Agents	**Epidemic gastroenteritis with severe diarrhea**
Reovirus	**Respiratory infections, gastroenteritis**
Protozoa	
Cryptosporidium	**Gastroenteritis**
Entamoeba histolytica	**Acute enteritis**
Giardia lamblia	**Giardiasis (diarrhea & abdominal cramps)**
Balantidium coli	**Diarrhea and dysentery**
Toxoplasma gondii	**Toxoplasmosis**
Helminth Worms	
Ascaris lumbricoides	**Digestive disturbances, abdominal pain.**
Ascaris suum	**Can have symptoms: coughing, chest pain.**
Trichuris trichiura	**Abdom. pain, diarrhea, anemia, weight loss**
Toxocara canis	**Fever, abdominal discomfort & muscle aches**
Taenia saginata	**Nervousness, insomnia, anorexia.**
Taenia solium	**Nervousness, insomnia, anorexia.**
Necator americanus	**Hookworm disease**
Hymenolepis nana	**Taeniasis**

*** Not all pathogens are necessarily present in all biosolids and manures, all the time.**

Methods for Meeting 40 CFR 503 Pathogen Requirements

The U.S. EPA 40 CFR 503 regulations, specifically 503.32(a) and (b), require biosolids intended for agricultural use to meet certain pathogen and vector attraction reduction conditions. The intent of a Class A pathogen requirement is to reduce the level of pathogenic organisms in the biosolids to *below detectable levels.* The intent of the Class B requirements is to ensure that pathogens have been reduced to levels that are unlikely to pose a threat to public health and the environment under the specific use conditions. For Class B material that is land applied, site restrictions are imposed to minimize the potential for human and animal contact with the biosolids for a period of time following land application until environmental factors have further reduced pathogens. No site restrictions are required with Class A biosolids. Class B biosolids cannot be sold or given away in bags or other containers. The criteria for meeting Class A requirements are shown in Table B-2, and criteria for Class B are shown in Table B-3.

Table B-2. Criteria for Meeting Class A Requirements

Parameter	Unit	Limit
Fecal Coliform or Salmonella	MPN/g TS*	1000
	MPN/4g TS	3
AND, **one of the following process options**		
Temp/Time based on % Solids	Alkaline Treatment	
Prior test for Enteric Virus/Viable Helminth	Post test for Enterec Virus/Viable Helminth Ova	
Composting	Heat Drying	
Heat Treatment	Thermophilic Aerobic Digestion	
Beta Ray Irradiation	Gamma Ray Irradiation	
Pasteurization	PFRP** Equivalent Process	

* Most probable number per gram dry weight of total solids

** Process to Further Reduce Pathogens; see Glossary in this document, and the EPA, Plain English Guide to Part 503

Table B-3. Criteria for Meeting Class B Requirements.

Parameter	Unit	Limit
Fecal Coliform	MPN or CFU/g TS*	2,000,000
OR, **one of the following process options**		
Aerobic Digestion	Air Drying	
Anaerobic Digestion	Composting	
Lime Stabilization	PSRP** Equivalent	

* Most probable number or colony -forming units per gram dry weight of total solids
** Process to Significantly Reduce Pathogens; see Glossary in this document, and the EPA, Plain English Guide to Part 503

Vector Attraction Reduction (VAR)

Under Subpart D of the Part 503 rule, safety and health protection with regard to biosolids management requires that biosolids meet one of 12 options to demonstrate vector attraction reduction, VAR (specifically 503.33). Options 1 - 8 consist of operating conditions or test to demonstrate VAR in treated biosolids, whereas options 9 - 11 use the soil as a barrier to prevent vectors from coming in contact with the biosolids. Materials that meet VAR 1 - 8 at the WWTP require less management at the storage site than biosolids without VAR treatment. All Class B biosolids that are stored require the same level of protection by site management as are provided by Class B site restrictions for land application.

Options prescribed for VAR are shown in Table B-4, and although these are not federally binding on biosolids storage operations, they do apply to the biosolids that are released from storage for land application. Some of these options rely on reducing the volatile solids in biosolids, and this can contribute to increased stability of the material, which is often associated with odor reduction. Furthermore, proper storage can assist in volatile solids reduction and as such in meeting vector attraction reduction requirements applicable to the use and disposal of biosolids according to Part 503.

The descriptions of the VAR methods presented in the regulation are treatment standards and descriptions only, but additional guidance is available (see EPA, 1992, EPA, 1995, Farrell et. al. 1996 in Chapter 4 references) which explains the rationale for the options. Also, Smith et. al. (1994) in another EPA guidance document provide direction on sampling and testing protocols.

Table B-4. Summary of Requirements for Vector Attraction Reduction Options.

Option	Requirement	Where/When Requirements must be met
1 Volatile Solids (VS) Reduction	≥ 38% VS reduction during solids treatment	Across the process
2 Anaerobic benchscale test	< 17% VS loss, 40 days at 30°C to 37°C (86°F to 99°F)	On anaerobic digested biosolids
3 Aerobic benchscale test	< 15% VS reduction, 30 days at 20°C (68°F)	On aerobic digested biosolids
4 Specific Oxygen Uptake Rate	SOUR at 20°C (68°F) is ≤ 1.5 mg oxygen/hr/g total solids	On aerobic stabilized biosolids
5 Aerobic Process	≥14 days at > 40°C (104°F) with an average > 45°C (113°F)	On composted biosolids
6 pH adjustment	≥ 12 measured at 25°C (77°F)*, and remain at pH > 12 for 2 hours and ≥11.5 for 22 more hours	When produced or bagged
7 Drying without primary solids	≥ 75% Total Solids (TS) prior to mixing	When produced or bagged
8 Drying with primary solids	≥ 90% TS prior to mixing	When produced or bagged
9 Soil Injection	No significant amount of solids is present on the land surface 1 hour after injection. Class A biosolids must be injected within 8 hours after the pathogen reduction process.	When applied
10 Soil Incorporation	≤ 6 hours after land application; Class A biosolids must be applied on the land within 8 hours after being discharge from the treatment process.	After application
11 Daily cover at field site	Biosolids placed on a surface disposal site must be covered with soil or other material at the end of each operating day.	After placement
12 pH adjustment of septage	≥ 12 measured at 25°C (77°F)*, and remain at ≥ 12 for 30 minutes without addition of more alkaline material.	Septage

* or corrected to 25°C

References

see Chapter 4 References.